NYU PHIL-UA 88, Spring 2022

HOW SCIENCE WORKS

Time & Place Mondays and Wednesdays, 9.30 to 10.45 AM
Kimmel 808

Texts *The Knowledge Machine*, Michael Strevens, Liveright, 2020.

- *Making Modern Science*, Peter Bowler and Iwan Rhys Morus, 2nd edition, University of Chicago Press, 2020. (The first edition will do at a pinch.)
- *The Structure of Scientific Revolutions*, Thomas Kuhn, University of Chicago Press, 2012. (Any edition that contains Kuhn's postscript will work. The pagination is just very slightly different in the latest edition.)
- Readings distributed via NYU Brightspace

Topics What is science? How does it work? Is there a scientific method? We will use a mix of logical argument, history, and sociology to investigate these questions. We will read the philosophers of science Karl Popper and Thomas Kuhn, as well as the early modern thinker Francis Bacon, and we will look at the history of scientific inquiry into the structure of the solar system, gravitation, the nature of heat, the question of the age of the earth, evolutionary theory, continental drift, and some modern physics including quantum theory. We'll travel into the lab with sociologists of science such as Harry Collins and Bruno Latour, as well as taking a more high-level look at the social organization of science and at the problems involved in "following the science" when formulating public policy to deal with climate change and covid-19.

Objectives Understand the debate about the nature of the scientific method; acquire familiarity with the ideas of some major thinkers about method

Learn to think critically about what is subjective and what is objective in scientific reasoning and argument

Appreciate the complexities and complications of scientific inquiry, both in conducting experiments and in evaluating the resulting evidence

Acquire some familiarity with a variety of illuminating episodes in the history of science

Learn some of the techniques used by sociologists to investigate science at both the micro and the macro level

Understand some aspects of the large-scale social organization of science; consider some proposals for reform

Understand some of the problems involved in applying scientific knowledge when formulating public policy

And finally: find out how science really works!

Evaluation Your total grade will be made up of:

First paper (due Mar 9)	20%
Second paper (due Apr 25)	20%
Exercises (due Feb 14, Mar 23, Apr 13, May 4)	20%
Class participation	10%
Take-home exam (due May 16)	30%

Papers should be about 1200 words long (roughly four pages). No extensions will be granted (except for medical emergencies).

Answers should be 300 to 500 words long (roughly a page to a page and a half). Don't write more than a page and a half. No extensions will be granted (except for medical emergencies).

The take-home exam will be distributed in the final class (May 9). You will choose three questions from a longer list, and write answers of about 600 words each (roughly two pages; six pages total).

Participation means some combination of: turning up for class and recitations; making useful remarks or asking valuable questions in class and recitations; finding interesting and relevant examples in the science news or elsewhere to share with the class.

Attendance at lectures and recitations is not required, but absence or lateness will be noted, and will have a major impact on your participation grade.

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Moses Center as early as possible in the semester for assistance.

Integrity Academic integrity means that the work you submit is original. Bringing answers into an examination or copying all or part of a paper straight from a book, the Internet, or a fellow student is a violation of this principle. But there are other forms of cheating or plagiarizing which are just as serious—for example, presenting an oral report drawn without attribution from other sources (oral or written); writing a sentence or paragraph which, despite being in different words, expresses someone else's ideas without a reference to the source of the ideas; or submitting essentially the same paper in two different courses (unless both instructors have given their permission in advance). Receiving or giving help on a take-home paper, examination, or quiz is also cheating, unless expressly permitted by the instructor (as in collaborative projects).

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READINGS

Sources identified as "resources" (and itemized with a ◇) are to be examined rather than read. It should be obvious what level of engagement is feasible, but we will give you some guidance in the course of the semester.

Introduction

Jan 24 Science and the Scientific Revolution
- ▷ Strevens, *Knowledge Machine*, Introduction
- ▷ Bowler & Morus, *Making Modern Science*, chapter 2 (pp. 25–57)

Read both at your leisure

Karl Popper's Falsification

Jan 26 Falsificationism
- ▷ Strevens, *Knowledge Machine*, pp. 13–22
- ▷ Popper, *Logic of Scientific Discovery*, pp. 3–24, 27–29, 57 (intro to chapter 4), 60–67 (starting at "Thus my conflict. . . ")

Jan 31 Eddington's eclipse experiment
- ▷ Stanley, "An expedition to heal the wounds of war"
- ◇ Resource: Dyson, Eddington, and Davidson, "A determination of the deflection of light"

Feb 2 Auxiliary assumptions
- ▷ Popper, *Logic of Scientific Discovery*, pp. 264–273, 278–282
- ▷ Strevens, *Knowledge Machine*, chapter 3, pp. 66–74
- ▷ Douglas, "Inductive risk and values in science"

Feb 7 The age of the earth
- ▷ Bowler & Morus, *Making Modern Science*, chapter 5 (pp. 108–133)
- ▷ Strevens, *Knowledge Machine*, chapter 3, pp. 74–86

Thomas Kuhn's Paradigms

Feb 9 Kuhn on normal science
- ▷ Kuhn, *Structure*, chapters 1 through 6

Feb 14 "A detail and depth that would otherwise be unimaginable" ◁ *Due date*
- ▷ Strevens, *Knowledge Machine*, chapter 1, pp. 32–38
- ▷ Wade, *The Nobel Duel*, chapter 8 (pp. 102–118)
- ▷ Waldrop, "Of politics, pulsars, death spirals—and LIGO"
- ◇ Resource: Daw, "How does an experiment at LIGO actually work?", https://phys.org/news/2016-02-ligo.html
- ◇ Resource: "Gravitational waves detected 100 years after Einstein's prediction" (LIGO press release), https://www.ligo.caltech.edu/news/ligo20160211
- ■ First exercise due

Feb 16 Kuhn on crisis and revolution
- ▷ Kuhn, *Structure*, chapters 7 through 9, 12 (omit pp. 96–103)

Feb 21 President's Day – no class

Feb 23 Kuhn on revolution and progress
- ▷ Kuhn, *Structure*, Postscript
- ▷ Strevens, *Knowledge Machine*, rest of chapter 1 (pp. 22–32, 38–40)

The Sociological Eye

Feb 28 Into the laboratory
- ▷ Latour and Woolgar, *Laboratory Life*, 15–21, 45–56, 142–149, 151–159
- ▷ Collins, "The seven sexes", 208–216

Mar 2 No class

Mar 7 Feminist critiques
- ▷ Richardson, "Sexes, species, and genomes"
- ▷ Okruhlik, "Gender and the biological sciences"

Mar 9 No class ◁ *Due date*
- ■ First paper due

Mar 21 Continental drift & subjectivity in science
- ▷ Bowler & Morus, *Making Modern Science*, chapter 10 (pp. 245–261)
- ▷ Strevens, *Knowledge Machine*, chapter 2 (pp. 41–65)
- ◇ Resource: Bekelman, Li, and Gross, "Scope and impact of financial conflicts of interest in biomedical research: A systematic review"

Science's Iron Rule

Mar 23 Bacon's new method ◁ *Due date*
- ▷ Bacon, *The New Organon*, Book I §§38–65, Book 2 §§1–20
- ▷ Strevens, *Knowledge Machine*, pp. 105–109 (optional)
- ■ Second exercise due

Mar 28 The iron rule
- ▷ Bowler & Morus, *Making Modern Science*, chapter 3, "The chemical revolution" (pp. 58–82)
- ▷ Strevens, *Knowledge Machine*, chapter 4 (pp. 89–104); chapter 5, pp. 109–119

The Newtonian Revolution

Mar 30 Newton's theory of gravitation
- ▷ Weinberg, *To Explain the World*, pp. 225–247
- ◇ Resource: Newton, *The Principia*, General Scholium to the second edition (pp. 585–590)

Apr 4 Explanatory relativism and shallow explanation
- ▷ Dear, *The Intelligibility of Nature*, chapter 1, pp. 15–28
- ▷ Aristotle, *Physics*, II.8
- ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 120–142

Apr 6 The quantum shallows; Whewell's God
- ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 142–151
- ▷ Strevens, *Knowledge Machine*, chapter 8, pp. 173–183
- ▷ Whewell, *History of the Inductive Sciences*, volume III, Book 18, Chapter 6, §§1, 5 (pp. 569–570, 580–588)

Apr 11 Only empirical evidence counts!
- ▷ Strevens, *Knowledge Machine*, chapter 8, pp. 183–197
- ▷ Christianson, *Isaac Newton*, chapters 3, 7 (pp. 24–33, 63–76)

Apr 13 Sterilizing the public record; The replication crisis ◁ *Due date*
- ▷ Strevens, *Knowledge Machine*, chapter 7 (pp. 152–172)
- ▷ Aschwanden, "Science isn't broken", https://fivethirtyeight.com/features/science-isnt-broken/
- ◇ Resource: Try out the *p*-hacking simulator in the Aschwanden piece
- ■ Third exercise due

Religion, Beauty, and Irrationality in Science

Apr 18 Religion and science
- ▷ Bowler & Morus, *Making Modern Science*, chapter 6 "The Darwinian Revolution" (pp. 134–171)
- ▷ Bowler & Morus, *Making Modern Science*, chapter 16, pp. 391–396

Apr 20 Is non-empirical thinking irrational?
Or is science irrationally narrow?
- ▷ Strevens, *Knowledge Machine*, chapter 9 (pp. 201–208)
- ▷ Strevens, *Knowledge Machine*, chapter 10, pp. 209–227

Apr 25 Beauty as a guide to truth ◁ *Due date*

- ▷ Strevens, *Knowledge Machine*, chapter 10, pp. 227–238
- ▷ Hossenfelder, *Lost in Math*, chapter 2 (pp. 17–41)
- ▷ Baggott, "But is it science?", https://aeon.co/essays/post-empirical-science-is-an-oxymoron-and-it-is-dangerous
- ◇ Resource: Gell-Mann, "Symmetries of baryons and mesons"
- ■ Second paper due

The Social Organization of Science

Apr 27 Credit capitalism

The reward system in science: who gets how much credit for what discoveries

- ▷ Merton, "Priorities in scientific discovery", pp. 635–646 (stop before *Humility*), 658–659
- ▷ Latour and Woolgar, *Laboratory Life*, pp. 200–208
- ▷ Casadevall and Fang, "Reforming science"
- ◇ Resource: Crick and Watson, "A structure for deoxyribose nucleic acid"

May 2 Data socialism

Merton's "communist" norm and information sharing in science

- ▷ Merton, "The normative structure of science"
- ▷ Louis, Jones, and Campbell, "Sharing in science"
- ▷ Strevens, "Scientific sharing: Communism and the social contract", first 9 pages (pp. 3–11)

Science and Public Policy

May 4 The voice of science ◁ *Due date*

Methods for deciding when science has reached a consensus, given that it never reaches a consensus

- ▷ Oreskes, "The scientific consensus on climate change"
- ■ Fourth exercise due

May 9 How to "follow the science"

The job of interpreting science for politicians, policy-makers, and the public

- ▷ Strevens, *Knowledge Machine*, chapter 14 (pp. 278–290)
- ▷ Schneider, "Confidence, consensus and the uncertainty cops: Tackling risk management in climate change"
- ◇ Resource: IPCC Fifth Assessment Report – Synthesis, at https://www.ipcc.ch/report/ar5/syr/

Papers are due on Mar 9 and Apr 25

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